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Astronomy Group

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Research Activities

(I) STAR

a. Stellar Structure and Evolution

A work done by M.NAKAMURA(Present Address: Fukuoka-District Meteorological Observatory) together with Y.NAKAKURA(Komaba High School, Tokyo) was published[1]. In this paper, a new contact condition including pressure terms is derived and applied in order to see the effect of pressure in common envelope on the evolution of a binary system in contact phase. Following the evolution of a low-mass system through the contact phase, it was found that the effect of pressure in common envelope is negligibly small and, therefore, the usual contact condition demanding the equality of the surface potentials of both components is reasonable.

b. Pulsating Stars

A paper of AIKAWA on radial pulsation of less massive supergiant stars was published[2]. In this work, linear and nonlinear investigations were performed a series of models with $M = 1\ M_\odot$ and $L = 3200\ L_\odot$. He suggested that the pulsation of FG Sge must have undergone mode-switching from the third overtone to the fundamental mode during its evolution toward later spectral types.

For studying modal coupling in Stellar pulsations, TAKEUTI[3] and UJI-IYE[4] investigated time-evolving hydrodynamic cepheid models. In a model a temporary enhancement of the first overtone mode, which was finally suppressed by the fundamental mode, is found. Because only the fundamental mode was implied to the model at the initial phase, the temporal enhancement is regarded as the result of modal coupling among pulsation modes, assumed in the Takeuti-Aikawa model of multi-modal stellar pulsations. Another temporal enhancement of finally suppressed modes are also shown in a model which has three pulsationally unstable modes.

c. Helium-rich Stars

NAKAJIMA's work on the circumstellar gas of σ Ori E, a helium-rich star, was published[5]. The gas trapped by the stellar magnetic field and corotating with the star was investigated. It was found that the gas concentrates to a potential minimum and forms either two condensations on a disc. The model gives good agreement with observation in the low obliquity case, and also explains the phase correlation among the Hα emission maximum, the light minimum, and the magnetic extreme. The model, however, failed to explain the large IR excess in the M band.

d. ε Aurigae

TAKEUTI[6] investigated pulsations of an F supergiant in an eclipsing binary, ε Aurigae system. He found that only a low-mass model can be allowed to explain its pulsation period and quasi-periodic variability. A model of an accretion disc surrounding a late B star was investigated. The disc seems to be a promising candidate for the eclipsing opaque object. TAKEUTI[7] continued his study of ε Aurigae during his stay at Konkoly Observatory of the Hungarian Academy of Sciences. A model of the disc consisted of three portion, an optically thin hot region just towards to the F star, an optically thick portion which can obscure the F star, and a cool portion only irradiated by the B star.

e. Accretion Discs, Magnetospheres and Bipolar Jets

An electrodynamical model was proposed by KABURAKI[8] to explain the mechanism which made white dwarf components in AM Her-type binaries rotate synchronously with their orbital motion. If a white dwarf were in asynchronous rotation, it acts as an unipolar inductor and drives a field-aligned current which closes it circuit through the secondary star. The Lorentz force acting on this current in the surface layer of the white dwarf causes a braking torque. It was shown that this mechanism worked far more effectively than the resistive process proposed by Joss, Katz and Rappaport.

KABURAKI investigated the structure of thin, Keplerian accretion discs which were threaded by the magnetic field lines of stellar origin. He obtained a fairely simple set of analytic solutions to the resistive MHD equations which were reduced under suitable assumptions. In this result, the field lines are swept up in the disc by accreting matter so that the field strength decreases more slowly with distance than in the case of initial dipolar field. The excess angular momentum in the disc is transported to the central star by the magnetic stress. As in the standard discs, it was shown that about a half of the gravitational energy was released in this non-viscous disc as the Joule heat. KABURAKI and ITOH applied this disc solution to the problem of explaining the optical jets from young stars. They illustrated that the jets could be accelerated and collimated by the presence of azimuthal magnetic field which the accreting matter had developed.

TAKEUTI[9)] investigated the vertical structure of a steady accretion disc surrounding a neutron star with the effect of X-ray irradiation from the central part. Incident X-rays and thermal radiations of the disc are treated in two-colour generalized Eddington's approximation. Numerical calculations were examined for annuli of which the surface temperature is less than ten thousands degrees K. The structure of disc is modified by X-rays, but the thickness is not increased remarkably.

Publications

1) The Effect of Pressure in the Common Envelope on the Contact Evolution of a Close Binary System, M. Nakamura and Y. Nakamura, Publ. Astron. Soc. Japan 37 (1985) 545 = Sendai Astronomiaj Raportoj N-ro 287.

2) Radial Pulsation of Less-Massive Yellow Supergiants. I. 1 $M_{\odot}$, 3200 $L_{\odot}$ Models, T. Aikawa, Astrophys. Space Sci. 112 (1985) 125 = Sendai Astronomiaj Raportoj N-ro 281.

3) Study of Time-evolving Hydrodynamic Cepheids, M. Takeuti, Astrophys. Space Sci. 119 (1986) 37.

4) The Analysis of Modal Coupling in a Hydrodynamic Model of Cepheids by the Maximum Entropy Method, K. Uji-iye, Science Reports Tohoku Univ. 8th Ser. 6 (1986) 173 = Sendai Astronomiaj Raportoj N-ro 292.

5) The Circumstellar Gas of Sigma Orionis E, R. Nakajima, Astrophys. Space Sci. 116 (1985) 285.

6) A Low-mass Model of Epsilon Aurigae, M. Takeuti, Astrophys. Space Sci. 120 (1986) 1 = Sendai Astronomiaj Raportoj N-ro 290.

7) An Accretion Disc surrounding a Component of Epsilon Aurigae, M. Takeuti, Astrophys. Space Sci. 121 (1986) 127.

8) Electrodynamical Synchronization of AM Herculis-Type Stars. O. Kaburaki. Astrophys. Space Sci. 119 (1986) 85.

9) The Steady Accretion Discs Irradiated by the Central Neutron Star, M. Takeuti, Science Reports Tohoku Univ. 8th Ser. 6 (1985) 1 = Sendai Astronomiaj Raportoj N-ro 283.

(II) GALAXIES AND INTERSTELLAR MATTER

a. Interstellar Medium and Star Formation

HASEGAWA[1] constructed a hydrostatic model of small, isolated dark clouds and studied their dynamical, thermal, and chemical equilibrium. Comparing calculated physical and chemical quantities with observed ones, he suggests that these dark clouds are not in the hydrostatic equilibrium.

SABANO and TOSA[2] studied fragmentation process of the interstellar molecular cloud which is predominated by supersonic turbulence. As a result of a collision of turbulent gas elements, a cold dense compressed layer is formed by shock waves. The compressed layer becomes gravitationally unstable and breaks into small fragments. The mass of the unstable fragment is estimated to be about two solar masses or less.

b. Dynamics and Evolution of Galaxies

FUKUNAGA[3] investigated the dynamics of the interstellar gas driven by the viscous torque of a system of Giant Molecular Clouds with the infinitesimally thin disk layer approximation. The giant molecular clouds flows radially and the flow explains the radial distributions of molecular radio emissions observed in galaxies.

KIMURA and TOSA[4] made a model calculation of motion of molecular gas clouds formed in the spiral shock waves to study the distribution of molecular cloud in the spiral galaxy M51. They showed how the global distribution of molecular clouds and the structure of the molecular arms depend on cloud's life time and the dynamics of the galaxy.

TOSA and FUKUNAGA[5] made N-body simulations of Giant Molecular Clouds system in a model galaxy and confirmed that their random motion is generated and accelerated by purely gravitational interaction among them in some 10^{7-8} years. The results of the simulation agree well with those of the previous theoretical calculation by Fukunaga.

KUMAI and TOSA[6] considered a galaxy moving in a cluster of galaxies to examine the effects of compression on the gas disc by the intergalactic gas. As a result of the compression, massive gas clouds are formed. Thus formed gas clouds are not stripped away from the galaxy by the dynamical pressure of the intergalactic gas but stay in the galaxy until they are disrupted by formation of massive stars.

FUJISHIMA, FUJIMOTO(Department of Physics, Nagoya University), and TOSA[7] made N-body simulation of disturbed galaxy to examine a conjecture that the compact nuclei of the active galaxies are resulted from the violent relaxation of the galactic core caused by external gravitational disturbances. They made a simulation of a disturbed galaxy by following orbits of gravitationally interacting particles but they found no appreciable enhancement of the core condensation.

SABANO and TOSA[8] made numerical calculation of the growth of thermal-chemical instability in a pre-galactic medium. They found that the thermal-chemical instability triggers a gravitational instability and a primordial gas cloud breaks into self-gravitating sub-condensations with mass of normal stars.

Publications

1) Hydrostatic Models of Bok Globules, T. Hasegawa, Astrophys. Space Sci. 119 (1986) 151.
2) Star Formation Induced by Supersonic Turbulence in Interstellar Molecular Cloud, Y. Sabano and M. Tosa, Astrophys. Space Sci. 115 (1985) 85.
3) On the Radial Distributions of Molecular Clouds in Galaxies, M. Fukunaga, Astrophys. Space Sci. 119 (1986) 143.
4) Distribution of Molecular Clouds in M51, T. Kimura and M. Tosa, Publ. Astron. Soc. Japan 37 (1985) 669.
5) N-Body Simulation of Giant Molecular Clouds in a Galaxy, M. Tosa and M. Fukunaga, Astrophys. Space Sci. 118 (1986) 463.
6) On the Effects of Compression of a Gaseous Disc by Thermal and Dynamical Pressures of Intergalactic Gas, Y. Kumai and M. Tosa, Astrophys. Space Sci. 119 (1986) 211.
7) Gravitational Perturbation on the Core of a Stellar System, Y. Fujishima, M. Fujimoto and M. Tosa, Publ. Astron. Soc. Japan 37 (1985) 415.
8) Thermal-Chemical Instability in a Pre-Galactic Gas Cloud, Y. Sabano and M. Tosa, Astrophys. Space Sci. 119 (1986) 167.

(III) OBSERVATIONS AND EXPERIMENTS

a. Radio Observations

Radio measurements of molecular emission lines were made by the radio astronomy group: TAKAKUBO, SEKI, HASEGAWA, KAMEYA, and HIRANO. (1) The core of the molecular cloud associated with NGC 7538 (HII region): Some results of CS$(J=1-0)$ and $C^{34}S$ $(J=1-0)$ measurements were shortly reported[1]. CO$(J=1-0)$ and ^{13}CO $(J=1-0)$ lines were measured using 45-meter telescope of Nobeyama Radio Observatory and it is now clear that the core region involves, at least, four high-velocity flows. (2) Barnard objects: Using 4-meter telescope of Nagoya University B1($C^{18}O$ $(J=1-0)$), B335(CO$(J=1-0)$), and B361(CO$(J=1-0)$ and $C^{13}O$ $(J=1-0)$) were observed. The reduction is in progress. (3) Software: Some softwares for data reduction, including high-quality graphics, were developed.

b. Optical Observations

Comet P/Halley: On the occasion before and after its perihelion passage, TAMURA, UJI-IYE, and SHIBATA tried to obtain spectral changes of emission bands in the wavelength regions of $\lambda\lambda$4200-5600 A with an intermediate-dispersion spectrograph, an intensified Reticon detector, and 91-cm telescope at Okayama Astrophysical Observatory. TANIGUCHI took direct photographs with 105-cm Schmidt telescope at Kiso Observatory in December 10 and 15, 1985 in collaboration with WATANABE(Tokyo Astronomical Observatory). TANIGUCHI and MATSUMURA took also spectrograms, which covered the wavelength region from λ3700 to λ6700 A, with an image intensified Cassegrain Spectrograph (the dispersion is 40 A/mm) and 188-cm telescope at Okayama Astrophysical Observatory.

Planetary Nebulae and Interstellar Medium: SHIBATA and TAMURA[2)] analyzed the stellar planetary nebula M1-9, spectroscopically, and concluded that it located at the galactic periphery and had the Helium rich chemical abundances. Therefore, it may have apparently compact size and be interpreted by the formation from the massive progenitor. TAMURA talked on Spectroscopic Analyses of Symbiotic Stars, which were related to planetary nebulae formation, at the second Japan-China workshop "Stellar Activity and Observational Thchnique" held at Kyoto. In order to do polarization measurements on interstellar scattering phenomena, MATSUMURA and SEKI[3)], at first, calculated the cross section and efficiency for polarization due to light scattering by spherical particles in the ultraviolet, optical, and near-infrared wavelength regions. They found that as far as the polarization is concerned, a typical interstellar grain scatters the light as in the Rayleigh scattering.

Galaxies: TAMURA obtained the relative color properties of clumps in irregular galaxies, Mrk 297 and Mrk 325 in UGR system of Kiso Observatory. He found that clumps of both galaxies were bluer than the Magellanic type of irregulars and showed scattering which may be due to a difference in stellar compositions. This work was done in collaboration with J. Heidmann(Observatoire de Paris) during Japan-France cooperative program co-sponsored by JSPS and CNRS. TANIGUCHI and TAMURA[4)] presented their work on high-dispersion spectroscopy of the clumpy irregular galaxies, Mrk 297 and Mrk 325 to mention internal gaseous motion and to estimate the virial masses of clumps. This work was also posted at IAU Symposium No. 115 "Star Forming Regions". TANIGUCHI[5)] discussed Hα emission line profiles of Starburst nuclei, NGC 838, NGC 7625, NGC 7714. He found the excess emission of the wing-like wide components. These samples show similar characteristics to narrow line regions of Seyfert nuclei. TANIGUCHI[6)] compared observational properties in detail between normal and starburst galaxies in order to investigate the nature of starburst activity in galaxies. He also presented spectroscopic results in optical regions on the fourteen supergiant HII regions of the galaxies with UV-excess continua. Contrary to expectations up to now, TANIGUCHI and

SHIBATA[7] together with WAKAMATSU(Gifu University) found 4 polar ring galaxies in rich clusters. In collaboration with M. WATANABE(Tokyo Astronomical Observatory), TANIGUCHI recently accomplished spectroscopic and surface photometric work on the blue early-type galaxy NGC 3928(= Mrk 190). They concluded that the peculiar nature of NGC 3928 is interpreted by an idea which the compact spiral disk is buried in the central region of large spheroidal component, and submitted their paper to Astrophysical Journal. TANIGUCHI, UMEMOTO, MATSUMURA made a survey for a Seyfert galaxy with a gas-poor companion (an elliptical or a lenticular) galaxy and found six unambiguous examples. This paper was submitted to Publ. Astron. Soc. Pacific.

Publications

1) CS, $C^{34}S$, and CH_3OH Observations of the Molecular Cloud associated with NGC 7538, O. Kameya, T. Hasegawa, N. Hirano, M. Seki, M. Tosa, Y. Taniguchi, and K. Takakubo, Astrophys. Space Sci. 118 (1986) 449.
2) Chemical Abundances of Stellar Planetary Nebula, Ml-9, near the Galactic Periphery, K. Shibata and S. Tamura, Publ. Astron. Soc. Japan 37 (1985) 325.
3) Polarization Efficiency and Phase Function Calculated on the Basis of the Mie Theory, M. Matsumura and M. Seki, Sci. Rep. Tohoku Univ. 8th Ser. 6 (1985) 11.
4) High-Dispersion Spectroscopy of the Clumpy Irregular Galaxies Markarian 297 and 325, Y. Taniguchi and S. Tamura, in "The Structure and Evolution of Ultraviolet-Excess Galaxies" edited by B. Takase and S. Tamura, p.23, 1986.
5) A Kinematical Study of Ionized GAs around Starburst Nuclei, Y. Taniguchi, in "The Structure and Evolution of Ultraviolet-Excess Galaxies" edited by B. Takase and S. Tamura, p.44, 1986.
6) A Statistical Study on the Difference between Normal and Starburst Galaxies, Y. Taniguchi, Sci. Rep. Tohoku Univ. 8th Ser. 6 (1986) 181.
7) New Polar-ring and Dark-lane Galaxies in Rich Cluster of Galaxies, Y. Taniguchi, K. Shibata and K. Wakamatsu, Astrophys. Space Sci. 118 (1986) 529.

(IV) NEW INSTRUMENTS

Personal computers NEC PC-98XAm2 system and NEC PC-9801Vm2 system.

Doctor Thesis

D1) Molecular Line Observations of the NGC7538 Molecular Cloud, Osamu Kameya.

Master Thesis

M1) Galaxy Formation, Toshio Uchida.
M2) The Theory of Geometrically Thin Accretion Disk, Norio Saitoh.
M3) The Age and He abundance Differences of Globular Clusters, Hiroshi Takemiya.
M4) Formation of Elliptical Galaxy, Akiko Nakamura.